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THESIS

APPLICATION OF A COMMERCIAL PRODUCT DEVELOPMENT PRACTICE TO MILITARY C4I SYSTEMS PRODUCT DEVELOPMENT

by

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Currently, most military C4I systems product development does not make effective use of customer input. Systems are developed and fielded in accordance with Department of Defense regulations that provide insufficient mechanisms for users to influence product requirements and design. C4I system program managers need additional tools to obtain and translate user needs into system requirements and designs.

Harvard Business School has developed an educational program aimed at redesigning product/service development based on the L.L. Bean model. This thesis applies the tenets of that program to submarine C4I systems development and identifies obstacles to and lessons learned from its application to military product development.

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APPLICATION OF A COMMERCIAL PRODUCT DEVELOPMENT PRACTICE TO MILITARY C4I SYSTEMS PRODUCT DEVELOPMENT

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I. INTRODUCTION

A. BACKGROUND

Customer-driven product development is a key component of successful commercial business practices in today's environment. Organizations such as L.L. Bean, Incorporated and Ford Motor Company integrate and ingrain the voice of the customer into their product development culture. Ford's Consumer Relationship Process is defined by "A sustained relationship with the consumer through the development of consumer insight, which is used in the development and delivering of products and services" (Renaud, 2000, p.8). This type of customer focus can benefit all organizations, both private and government. Ability to meet the needs of the customer can be the difference between success or failure in the commercial marketplace and in government systems development. Unfortunately, many barriers exist to successfully integrating the voice of the customer into military systems development. The Government Accounting Office (GAO) has issued a series of reports on the success that leading commercial firms have had in significantly reducing the time and money needed to develop new and more sophisticated products – the same results that the Department of Defense (DoD) desires. Significant cost and schedule increases, as well as significant user dissatisfaction, can be traced to an insufficient definition of customer requirements prior to program management decisions.

The basic process for formulating product requirements is the same for commercial firms and DoD. Understanding the customer's expectations is the first step for both. These expectations must then be translated into product requirements, including the functions,

characteristics, reliability and maintainability it must possess. It is not unusual that the first understanding of customer expectations exceeds the capacity of the product developer given the current state of technology as well as limited resources and time available. Table 1 highlights the contrasts between the interests of the customer and product developer.

Customer wants	**Product Developer's resources**
Performance: what the product should do. For example, what an aircraft's speed, range, fuel economy, reliability and other features should be.	Technology: the technology that is needed to make the product function to a level necessary to meet the customer's wants.
Timing: when the customer wants the product.	Schedule: the amount of time that is needed to develop, design, test and manufacture the product.
Pricing: what the product will cost. The customer must be able to afford the product.	Investment funds: the capital that is needed to pay for development, test, and manufacture of the product.
	Expertise: the capabilities of the product developer in terms of engineering expertise, manufacturing capabilities and production.

Table 1: Customer and Product Developer Interests in a Product's Developments (From: GAO Report 01-288, March 2001)

All product developments attempt to match customer expectations with available resources in order to define the product. The matching process leads to close scrutiny of the customer expectations and developer's resources, resulting in a set of product requirements that represent an agreement between the customer and developer on the product's planned performance, cost and schedule. This basic requirements process is depicted in figure 1 below.

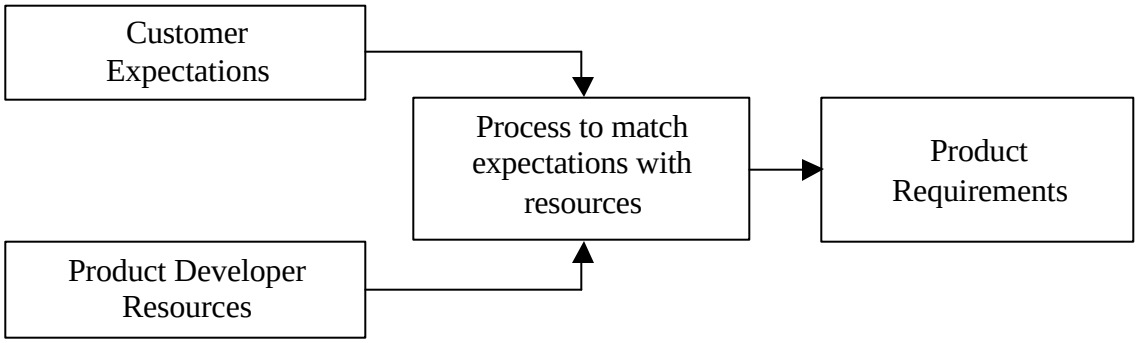

Figure 1: The Requirements Process (From: GAO Report 01-288, March 2001)

Translation of customer expectations into a set of specific product requirements includes information gathering, analysis and negotiation. In commercial product developments, these negotiations occur directly between the customer and product developer before resources are committed to the product development. During this process, the general customer expectations are reduced to a set of performance requirements that are achievable within the developer's available resources and still meet the customer's needs. Two-way communications occur between the customer and product developer during this process. For example, during new commercial aircraft development, the customer may desire a certain speed in order to enhance passenger revenue, but the developer determines that the time and resources available are insufficient to achieve that speed. Negotiation then ensues until both parties agree upon a speed requirement that satisfies the customer need within the available development resources.

DoD employs a more complex requirements process involving communication between at least four players. Separating the customer (an organization in the fighting

forces) and the product developer (a defense contractor), is the user representative (organization representing the customer in product requirements negotiations) and the DoD Program Manager (essentially representing the product developer in requirements negotiations) (GAO Report 01-288, pp 18-19). Figure 2 depicts the interplay between the major players in the commercial and DoD requirements processes.

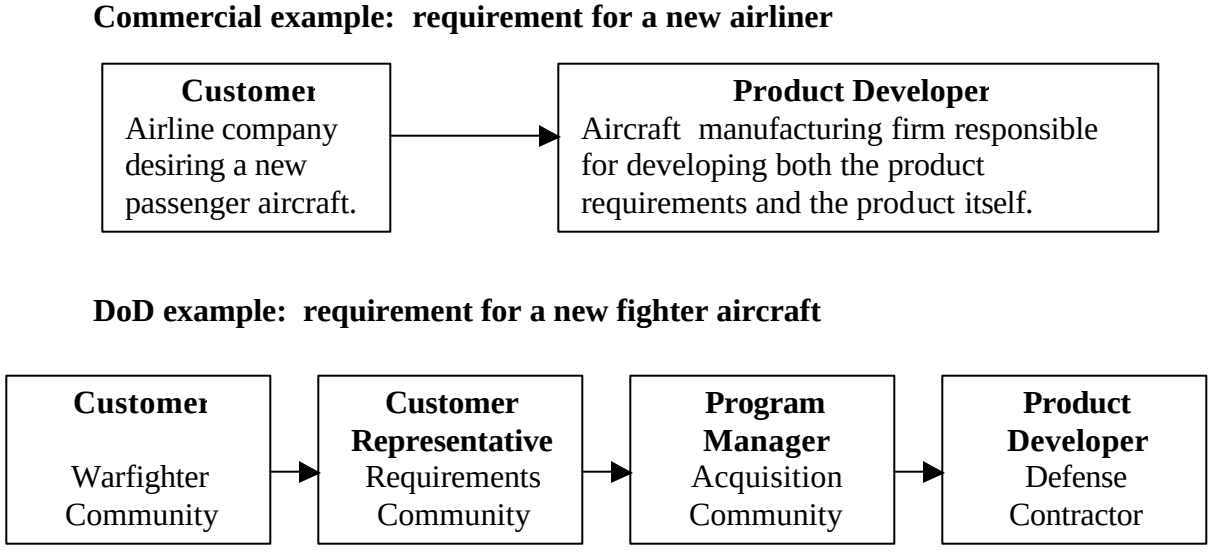

Figure 2: Commercial and DoD Organizations Involved in Requirements Setting Processes (From: GAO Report 01-288, March 2001)

Both commercial and defense organizations are concerned with the cost, schedule and performance aspects of a product's development, and these concerns are reflected in the final set of specific product requirements. In the defense process, however, the ultimate product developer usually has little input into the requirements development process. Formal product requirements, in the form of an Operational Requirements Document, are provided to the prime contractor at the start of the actual product development cycle.

B. PURPOSE

The purpose of this thesis is to evaluate the applicability of a specific commercial product development process used by L.L. Bean, Incorporated to define customer requirements to military C4I systems development. The most effective means of accomplishing this is by applying the tenets of that process to the development of specific military C4I systems. Submarine Exterior Communications Systems have been selected as the candidate systems to evaluate this approach as a result of the author's position within the Submarine Communications Program Office and extensive background in submarine operations and communications. This research includes interviews with submarine officers and enlisted communications personnel currently serving aboard fleet units. The specific interview questions are developed using the L.L. Bean model.

The results of this analysis will be used to enhance the development of the submarine C4I systems investigated in addition to assessing the applicability of the process to military C4I system development. Use of the L.L. Bean product development process should allow for enhanced communication of customer expectations directly to program office personnel, thus streamlining the requirements negotiation process depicted in Figure 2 above.

C. RESEARCH QUESTIONS

The following research questions fall into two categories. The first category of questions will be answered primarily through review of current literature. The second category will be answered by conducting interviews with submarine C4I system users using the L.L. Bean method and analyzing the results.

1. Research Questions Answered by Literature Research

Before applying the L.L. Bean model to submarine C4I system development, an investigation of current best practices in commercial customer-driven product development and military adaptation of these commercial best practices is required. Potential benefits and drawbacks of customer-driven military C4I systems product development should also be identified and researched. The following questions address these areas:

1. What are the current best practices in customer-driven commercial product development?
2. How have commercial best practices in customer-driven product development been adapted for military use?
3. What are the key elements to customer-driven product development (commercial or military)?
4. What are the benefits of customer-driven military C4I systems product development?
5. What are the drawbacks of customer-driven military C4I systems product development?
6. What are the special considerations required for customer-driven military C4I systems product development?

2. Research Questions Answered by Interview Results

The crux of this thesis is based on applying the L.L. Bean product development interview technique to submarine C4I systems development. The following questions were

used in adapting that technique to gather submarine officer and enlisted communications personnel expectations with regard to submarine C4I systems.

1. What type of interview questions allows users to convey their experiences and ideas regarding military C4I systems development and use?
2. What is the best way to conduct interviews with users to enhance military C4I systems product development?
3. What is the best way to analyze data collected during user interviews?
4. How can user statements during interviews be translated into military C4I system product requirements?
5. How can validated product requirements be translated into product design ideas?
6. How can product design ideas be incorporated into military C4I systems product development?

D. BENEFITS OF STUDY

The benefits of this study are twofold. First and foremost, the applicability of the L.L. Bean interview techniques for capturing the voice of the customer will be evaluated in a military systems development environment. If successful, this technique could provide defense program managers with a powerful tool to help define customer expectations and negotiate with users to develop product requirements that satisfy user needs within the constraints of the product development resources and timeframe available to the program manager.

Secondly, the Submarine Communications Program Manager will benefit by receiving direct user input regarding the performance and suitability of submarine C4I

systems onboard fleet units today. This information should enhance the program manager's decision-making ability regarding planned product development efforts, ultimately resulting in improved C4I products and systems and enhancing submarine force connectivity in the future.

E. SCOPE AND METHODOLOGY

1. Scope

The scope of this thesis is divided into five phases. The first phase involves a review of commercial product development best practices and their application to military systems. This phase is important to provide an understanding of successful product development practices currently in use. It will provide a baseline assessment for how well customer desires are captured and included in both the commercial and military product development process.

The second phase consists of a review of the Harvard Business School's Redesigning Product/Service Development program based on the L.L. Bean, Incorporated model. This phase is necessary to understand the L.L. Bean method of incorporating the voice of the customer into product development and to begin adapting that method for military C4I systems development.

The third phase consists of application of the tenets of the Harvard Business School's Redesigning Product/Service Development program to submarine C4I systems product development. Gathering data on customer expectations from submarine operators through targeted interview questions developed during phase two is the focus of this phase.

The fourth phase entails an in-depth analysis of submarine customer interviews conducted in accordance with the L.L. Bean model. The voice of the submarine customer can thereby be determined and used to enhance submarine C4I systems development. An assessment of the applicability of the L.L. Bean method to military C4I systems development will also be performed.

The fifth and final phase consists of translation of customer-expressed needs to submarine C4I systems product requirements development and design. This phase will allow program mangers developing submarine C4I systems to make decisions and trade-offs regarding cost, schedule and performance of developments under their cognizance.

The end result of this research is to test the L.L. Bean product development model in a military C4I systems environment. It will conclude with recommendations for future applications of the model.

2. Methodology

The methodology used in this thesis research consists of the following steps:

1. Conduct a literature review of books, magazine articles, CD-ROM systems, and other library information resources on customer-driven product development best practices.
2. Conduct a thorough review of previous research.
3. Conduct a review of the Harvard Business School's Redesigning Product/Service Development program based on the L.L. Bean model.
4. Examine the current military C4I systems product development model.

5. Develop submarine C4I system customer interview questions using the Harvard Business School program tenets.
6. Conduct submarine C4I system customer interviews in accordance with the L.L. Bean model.
7. Thoroughly analyze submarine C4I system customer inputs and translate them into system requirements and design ideas.
8. Evaluate efficacy of the Harvard Business School program as it relates to military C4I systems development.

F. ORGANIZATION OF STUDY

This study consists of six chapters, which describe current best practices in commercial product development and their application to military systems, the Harvard Business School's Redesigning Product/Service Development program based on the L.L. Bean model, and an application of it to submarine C4I systems development. Chapter I provides a brief introduction and summary of this thesis, including an assessment of the need for improved methods of collecting customer desires and expectations in military systems development. Chapter II consists of a literature review on best practices in commercial product development and their application to military systems. The L.L. Bean Product Development model is also described in detail here.

In Chapter III, the research methodology is described. This chapter explains the steps required in applying the L.L Bean model to submarine C4I system product development and the special considerations required. Chapter IV provides a detailed analysis of the results of submarine customer interviews. Chapter V provides an evaluation of the Harvard Business

School's Redesigning Product/Service Development program application to submarine C4I systems product development. Finally, Chapter VI summarizes this research, provides lessons learned and recommends further research areas.

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II. LITERATURE REVIEW

A. INTRODUCTION

In product development, satisfying customer needs is recognized as a key competitive success factor in today's commercial marketplace. Product development teams consisting of engineers and designers must be able to extract a high degree of detail regarding customer expectations in order to be successful. A laser-like focus on the customer is necessary to determine the best possible answers to the following product development relevant questions: (1) What exactly do customers value? (2) From these values, what are the product requirements that will achieve the highest possible level of customer satisfaction? (Renaud, 2000). The voice of the customer can provide a new product idea or suggest innovations for an existing product. Effectively engaging the customer voice enables a company or government program office to better understand how customers use their products. A product's success (or failure) can be a direct result of the company/program office's ability to understand and satisfy the voice of the customer.

To date, the degree of improvement in new product development methods has been higher in the commercial sector than the defense sector. The commercial world has integrated the customer voice throughout the organization as the primary means to improve product development. In DoD, institutional barriers can hinder widespread integration of the voice of the customer in product development. Government product developers tend to focus on development process and methods, providing less interaction with users during product development.

This chapter examines several current best practices in commercial product development and their application to military systems. It discusses how successful companies integrate the voice of the customer into their product development strategies, and how government program offices could benefit from similar strategies. The chapter then focuses on the Harvard Business School's Redesigning Product/Service Development program, describing how L.L. Bean, Incorporated integrates the voice of the customer into their product development process and how to apply the same principles to military product/service development efforts.

B. COMMERCIAL BEST PRACTICES

Many different techniques are employed by commercial organizations to obtain and use the voice of the customer during the product development process. Often, the method used to gain insight into the customer voice depends on the company's specific objective and type of information desired. Companies seeking meaningful feedback from a relatively large group of customers at once may employ the focus group method. Survey methods can provide insight on how customers rate specific product features. Worldwide Web-based methods, such as the Sloan School of Management's Information Pump have also been developed. Finally, one-on-one interviews can be used to provide detailed customer expectation data from individual users. Each of these methods has distinct strengths and weaknesses as discussed below.

1. Focus Groups

Product development practices using focus groups bring together multiple users in a single setting to gain insight from the group as a whole. A moderator is usually employed to

lead group discussions directed at obtaining customer expectations with regard to product features under consideration by the company's product development team. Focus group feedback can provide a good indication regarding how the larger customer population will likely react, allowing the company to evaluate whether or not they should proceed with a particular idea. A significant advantage of the focus group technique is that it allows for a variety of perspectives to be advanced and discussed in an open forum, often leading to frank and constructive product development inputs. However, the focus group technique can suffer if one or more individuals dominate the discussion and influence the overall group response. In most cases, "the focus group can provide helpful insight into the voice of the customer" (Mastronardi, 2001, p. 17).

2. Customer Surveys

Surveys can be provided to either a target set of customers or randomly to gain insight regarding how customers might perceive product or service features. Many types of surveys and methods of administering them are currently in use. Telephones, the Internet, mailings and face-to-face surveys at the point of sale can all be effective in capturing the voice of the customer. Advantages of the survey method include: (1) detailed data regarding customer perceptions of a product or service can be obtained and (2) statistically relevant metrics can be developed and displayed conveniently for decision-makers. The primary disadvantages of the survey method include the potential for a high numbers of non-responses and customer misunderstanding of questions leading to an incorrect assessment of customer product desires. Surveys can be useful in providing customer voice information to

companies, but their use is generally limited to more targeted roles than other methods (Mastronardi, 2001).

3. Information Pump

Drazen Prelec (Professor of Management Science, Sloan School of Management, Massachusetts Institute of Technology) has developed a method called the Information Pump focusing on providing incentives for collecting customer information. These incentives are integrated into a web-based information system for data collection relevant to the product design process. This incentive-based approach has the advantage of allowing for consistent motivation and effort by the customer, and the incentives clearly communicate the information desired from customers. By allowing customers to monitor their progress, improved responses can be obtained over time. This approach also identifies the most responsive customers who can then be used for later product development efforts. Two different approaches can be used to create incentives with customers: (1) linking compensation to the outcome of the project and (2) enabling the comparison of responses from two customers simultaneously via the Internet. The Information Pump can provide the voice of the customer via the Web and enable customers to compare and contrast desirable product features via web-based interaction with one another. This method also has the distinct advantage of incorporating a scoring method for qualitative and quantitative feedback (Mastronardi, 2001).

4. One-on-One Interviews

Direct interviews with targeted customers provide unfiltered feedback to companies regarding customer expectations that can be extremely useful to product development teams.

Questions posed to the interviewees are often open-ended to allow the interviewee to take the lead in discussions. An interview guide, developed beforehand, allows the interviewer to keep the discussions on track with the research objectives. The voice of the customer may express a product need, an area where a specific product or service fell short of expectations or even a product feature that created customer delight. One-on-one interviews can be invaluable in helping companies determine how their products are actually used and how they fit into their customers' lifestyle. The success of one-on-one interviews in revealing the voice of the customer is directly dependent on the structuring of interview questions to meet the desired objectives (Mastronardi, 2001). The Harvard Business School's Redesigning Product/Service Development method relies strongly on one-on-one interviews to understand customer expectations and integrate the voice of the customer into the product development process.

C. GOVERNMENT ADOPTION OF COMMERCIAL BEST PRACTICES

For several years, the Government Accounting Office (GAO) has been recommending the adoption of commercial best practices for DoD product development. Their opinion is "the best practices of leading commercial firms can be used to improve the development of technology and weapon systems in DoD" (GAO Report 99-116, p. 1). The best practices model advocated by GAO is based on developing knowledge to answer the basic question of how a capability can best be provided to the customer. Understanding the voice of the customer is a crucial first step in developing the requisite knowledge base advocated by the GAO. DoD regulations also recognize the importance of customer input. "The Defense acquisition and requirements communities shall maintain continuous and

effective communications with each other and with the operational user. The objective is to gain a sound understanding of the users' needs and to work with them to achieve a proper balance among cost, schedule, and performance considerations." (DoD Instruction 5000.1, Paragraph 4.2.2). To help foster the required "effective communications" with operational users, acquisition program offices could employ the Harvard Business School's Redesigning Product/Service Development method being evaluated herein.

GAO has also identified several successful DoD initiatives where commercial best practices have been adopted to enhance military system development. Examples include maturing technologies prior to incorporating them into programs of record (e.g., VIRGINIA (SSN 774) Photonics Mast, the Advanced Amphibious Assault Vehicle propulsion technology, and the Air Force's Integrated High Performance Turbine Engine Technology Program), emphasizing cost as an independent variable and utilizing integrated product teams to manage system development (GAO Report 99-116). Government program office success in adopting some commercial best practices indicate that others, such as those used to obtain and integrate the voice of the customer into product development, can be effectively adapted to enhance DoD processes.

D. HARVARD BUSINESS SCHOOL'S REDESIGNING PRODUCT/SERVICE DEVELOPMENT PROGRAM

Harvard Business School has developed a program titled "Redesigning Product/Service Development" based on the L.L. Bean, Incorporated process for obtaining the voice of the customer. This program provides a toolkit to guide product developers in its implementation in their own setting. The toolkit contains a video introducing the benefits

and steps of customer-driven product or service development, using L.L. Bean, Inc., as an example, a blueprint detailing how to apply the video techniques to other product or service development challenges and worksheets to facilitate organization of the customer-driven product development work. The material in the toolkit is based on the writing and research of Professor David A. Garvin. This program is described in detail in the paragraphs below.

1. L.L. Bean Model

The key points of the Harvard Business School customer-driven product development model can be summarized as follows (Garvin, 2000):

a. Customers are the real product or service experts.
b. Developing the best products or services requires understanding and bringing customer experiences right into the design shop.
c. Don't isolate product developers from customers with outside market researchers or focus group one-way mirrors. Immerse developers in customer experiences.
d. Go right to the customer's turf.
e. Listen to customers face to face.
f. Watch customers actually using products or services.
g. Translate what you see and hear into the customer's essential product or service requirements
h. Develop product or service designs that precisely meet those essential requirements
i. Highlight this customer-driven approach in your marketing.

The video provided in the Harvard Business School program toolkit depicts actual L.L. Bean product developers applying these key points to the development of new products. The blueprints and worksheets provide a framework for adapting these tenets and methods to other products and services.

2. Criteria for Field Testers

The early stages of customer-driven product or service development rely on a very small group of customers (approximately 16-20). If properly selected, this group can be used again and again to help develop new products or services and improve existing ones. Thus, field tester selection is a critical part of the process. The goal is to form a group of field testers who are: (1) experienced users of the target product/services, (2) demographically diverse, and (3) articulate, honest communicators. The Harvard Business School program begins with the definition of field tester selection criteria, and then applies those criteria to select field testers from the customer base. This process proceeds in the following steps (Garvin, 2000):

a. Definition of users versus purchasers – although it may be useful to talk with purchasers of products and services, it is essential to listen to and watch customers who actually use the products and services. For example, parents purchase toys, but children are the actual users of toys.

b. Definition of experienced users – only about 16-20 customers will become field testers, so it's important to choose them from the most experienced product/service users. For example, experienced users may be defined as those customers who use X quantity of products or services within Y period of time.

c. Definition of demographic categories from which diverse representation is needed among experienced users – ensuring diversity among experienced users will provide a broader range of perspectives regarding the products or services. For example, demographic categories can be defined by occupation, gender, age, etc.

d. Definition of common characteristics for experienced, demographically diverse users – the most valuable, experienced, demographically diverse users should have certain characteristics in common. For example, L.L. Bean ensures its field testers are articulate communicators, analytical in comparison of their products, honest and unbiased, and timely in providing feedback.

3. Field Tester Interviews

The field tester interview process described in the Harvard Business School's Redesigning Product/Service Development program is based on open-ended interviewing techniques that have roots in anthropology (see Schwartzman, pp. 58-60, 66). Two key areas of focus for the field tester interviews include the interview questions and the interview pairs.

The interview questions should enable the field testers to convey the depth of their experiences with the product/service by vividly describing what happens and how they feel when using them, explaining what problems they've had in using them, and expressing their excitement regarding them. The questions must be broad and open-ended to promote in-depth answers, be non-leading so as not to suggest any particular answer, explore comparison's with other products/services and take no more than an hour of the field tester's time. The final list of question should be narrowed down to no more than five or six. L.L.

Bean uses the following types of questions when interviewing hunters who use their boots (Garvin, 2000, p. 29):

- "Tell me your best hunting story."
- "Describe a situation in which your hunting footwear let you down."
- "If you could design your own custom hunting boots, what would they be like?"
- "What haven't I asked you about your footwear that you'd like to discuss?"

The Harvard Business School program also stresses the need to conduct the interviews using a pair of interviewers with distinct roles – an interviewer and a recorder. The interviewer encourages field testers to describe their experiences and feelings to say what is on their minds, listens attentively, never interrupts and redirects the interviewee only when absolutely necessary. For example, the interviewer might ask the field tester to say more about his or her experiences if the tester had jumped to product/service solutions prior to providing a clear picture of their specific experience. The recorder remains silent and attentive, writes down exactly what the field tester says, doesn't interpret, filter or summarize the field tester's words, and asks for clarification if he doesn't understand the tester's comments. The method also allows the recorder to discreetly operate a small recording device if the field tester is comfortable being recorded, but it notes that most people prefer not to be recorded. A recorded transcript of the interview can be useful, but it is not essential if the written transcript is carefully maintained (Garvin, 2000).

4. Interview Data Analysis

Analysis of the data collected during field tester interviews is conducted in two parts: (1) post-interview debriefings and (2) summarizing field tester quotations and descriptions.

Post-interview debriefings should be conducted as soon as possible after each interview. The debriefing allows the interviewer and recorder to review their notes and fill in any gaps. As they're reviewing, they can also begin to capture what the field testers think and feel most deeply about their products/services, selecting evocative quotations and vivid descriptions and recording them on sheets of paper headed with each interview question. For example, L.L. Bean hunter interviews provided the following types of evocative quotations and vivid descriptions (Garvin, 2000, p. 33):

- "walking through wet, swampy areas – water seeping into my boots"
- "pulling socks way up because the boot rubs and rubs and rubs – hair rubbed right off"
- "putting on wet, cold boots in the morning – just miserable"

The next step is to summarize and translate these field tester quotations and descriptions using the following steps (Garvin, 2000):

a. Pool quotations and descriptions – posting each interview question on the wall and putting each quotation and description under the appropriate question provides one method to accomplish this.

b. Prioritize and Reduce pooled quotations and descriptions – apply your understanding of field tester priorities.

c. Group prioritized quotations and descriptions – remove the interview questions from the wall and rearrange the quotations and descriptions into clusters by themes.

d. Summarize grouped quotations and descriptions – distill the essence of each cluster of field tester quotations and descriptions into a brief statement. For example, the first and

third quotation listed earlier in this section regarding L.L. Bean hunting boots could be grouped under the summary statement, “Feet wet and cold”.

5. Translation of Interview Results into Product Requirements and Design Ideas

Each quotation/description summary statement developed from the field tester interview analysis is then translated into many field tester requirements. For example, the summary statement, “Feet wet and cold” could be translated into two requirements for the hunter’s footwear: (1) keep the feet dry and (2) keep the feet warm. All of the product requirements thus generated are then pooled, prioritized and reduced, grouped into prioritized requirements and then further prioritized and reduced. The final set of prioritized product requirements should not contain any redundant requirements and should accurately capture the field tester’s priorities. After obtaining a set of valid requirements, each is translated into many design ideas. For example, the requirement to keep the feet warm might create design ideas for flannel sock liners or insulated boot inserts. All of the design ideas thus generated are pooled, prioritized and reduced, grouped into prioritized design ideas and then further prioritized and reduced. The final set of grouped design ideas should not contain any redundant ideas, should precisely meet the valid requirements and be logistically realistic. The final set of design ideas should also be compared to the field tester quotations and descriptions to ensure that the ideas and concerns of the experienced, demographically diverse product/service users are still driving the development (Garvin, 2000).

E. SUBMARINE C4I SYSTEMS OF INTEREST

Three submarine C4I systems of interest were selected for this study to assess the applicability of the Harvard Business School's Redesigning Product/Service Development program and to provide useful feedback to the Space and Naval Warfare Systems Command Submarine Communications Program Office regarding planned product enhancements for currently fielded systems and future new product developments. Each system and the reason for its selection are described briefly in the paragraphs below.

1. Ultra High Frequency (UHF) Medium Data Rate (MDR) Capability

Installation of UHF MDR capability on submarines provides a 32 kilobit per second (kbps) UHF asymmetric satellite communications capability to support Internet Protocol (IP) connectivity, enabling web browsing and e-mail SIPRNET services for the submarine while underway. UHF MDR is installed on all fast attack submarines deploying with Battle Groups to provide an interim medium data rate IP capability prior to the fielding of Submarine High Data Rate antenna. The program office perceives the UHF MDR program as an acquisition success story due to it's relatively low cost, it's rapid speed to deployed capability and it's importance to future communications concepts of operations. It is of interest to this study and to the Submarine Communications Program Office to determine how well the UHF MDR capability was meeting the fleet need for SIPRNET connectivity and obtain the voice of the submarine customer perspective regarding needed upgrades for the system.

2. Mini-DAMA UHF Transceiver

The AN/USC-42(V) Miniaturized Demand Assigned Multiple Access (Mini-DAMA) Program consists of Non-Developmental Item/Commercial Off-The-Shelf (NDI/COTS) equipment to provide a communication system that supports the exchange of secure and non-secure Battle Group coordination data, tactical data and voice. This system is of interest to this study because of the multiple design and logistics problems involved with its fielding on operational submarines and the desire to capture the voice of the submarine customer during development of planned field changes/upgrades.

3. Submarine Tactical Data Links

Submarine Tactical Data Links currently in use onboard operational submarines include LINK 11, LINK 16 and Satellite TADIL-J (S-TADIL-J). These systems allow near real time transfer of tactical track data (course, speed, identification, etc. of contacts) between submarines and other Battle Group units. These systems are of interest to this study to help evaluate which of these systems submarine customers actually use and to capture the voice of the submarine customer in defining product requirements for systems under currently under development to replace these older, legacy tactical data transfer systems.

F. CHAPTER SUMMARY

This chapter reviewed commercial best practices used to integrate the voice of the customer into product development, along with successful examples of DoD adaptation of other commercial best practices. The Harvard Business School's Redesigning Product/Service Development program based on the L.L. Bean, Incorporated, product

development model was described in detail. This method emphasizes face-to-face interviews with experienced product users, called field testers, using open-ended questions conducted by two person interview teams. Interview data are analyzed to provide field tester quotations and descriptive phrases that are further developed into product/service requirements and design ideas. This chapter also provided a brief description of submarine C4I systems of interest that will serve as the test case for application of this commercial product development process to military C4I systems development. The remaining chapters of this research will describe the application of the Harvard Business School process to the conduct of submarine user interviews and development of submarine C4I system product requirements and design ideas.

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III. RESEARCH METHODOLOGY

A. INTRODUCTION

The purpose of this research is to apply the Harvard Business School's Redesigning Product/Service Development method of obtaining the voice of the customer to submarine C4I systems development, evaluating the applicability of this commercial product development process to military systems development. The research methodology is divided into three main areas as defined by the Harvard Business School program. The first area involves planning the product development interviews to include determining the composition of the interview team and developing the questions to be used during the interview. Because the goal is to assess the applicability of the Harvard Business School program to military systems development, the tenets of that program are followed as closely as possible in planning the submarine customer interviews. Careful preparation and development of the interview guide will help keep the subsequent interviews focused and effective.

The second major area of research methodology involves selecting field testers from the submarine community to interview. Again, the Harvard Business School process is followed as closely as possible and adapted where necessary to include submarine-specific criteria. Proper definition of submarine field tester criteria is critical to ensure useful feedback is obtained regarding the selected submarine C4I systems of interest and to adequately assess the applicability of this commercial product development process to military systems.

The final area of research methodology is the conduct of the interviews themselves. In order to analyze the effectiveness of the L.L. Bean product development method in this context, feedback must be obtained directly from the selected submarine field testers. The interview questions developed in accordance with the Harvard Business School program guidelines are used to guide the discussions with the submarine field testers and their responses are recorded exactly. In order to accurately capture the voice of the submarine customer, the interviews are conducted on their home turf aboard their submarines. The results of these interviews help generate conclusions and recommendations regarding the applicability of the Harvard Business School program to military systems development and provide useful data for the Submarine Communications Program Office efforts to improve existing products and develop new ones.

B. PLANNING PRODUCT DEVELOPMENT INTERVIEWS

The first step in applying the Redesigning Product/Service Development methodology is to plan the product development interviews. Two key areas of initial interview planning are the composition of the interview team and the development of interview questions used to guide the discussions with field testers. Both of these areas are discussed separately below.

1. Interview Team Composition

The Harvard Business School's Redesigning Product/Service Development program is quite specific regarding the necessary interview team composition. Two persons make up the interview team – one takes the role of interviewer and the other acts as recorder. The interviewer facilitates the interview using open-ended questions as a guideline and

encouraging field testers to vividly describe their experiences and feelings regarding the product being discussed. The recorder remains silent during the interview except to ask for clarification when required and writes down exactly what the field tester says.

For the submarine customer product development interviews, the author acted as interviewer, applying his fifteen years of submarine operating experience and communications systems expertise to enhance the conduct of the interviews. Selected submarine field testers appreciated the interviewer's detailed understanding of their operating environment and assigned missions. Due to the technical nature of the interview discussions, it was important that the interviewer be a subject matter expert in the area of submarine operations and communications. A group discussion facilitator (Mr. Gary Rossi) from Booz, Allen and Hamilton, Inc. was selected to act as the recorder for the submarine customer product development interviews. Mr. Rossi also had previous experience as a Naval Officer prior to his employment at Booz, Allen and Hamilton. The interview team worked closely together to learn and apply the tenets of the L.L. Bean product development process to plan and conduct the interviews.

2. Interview Questions

The L.L. Bean product development interview process as described in the Harvard Business School's Redesigning Product/Service Development program is also very specific with regard to interview question generation. In order to promote detailed, in-depth discussions with the submarine field testers, the questions need to be broad and open-ended. They must not lead the interviewees to any particular answer and should take no more than one hour of the submarine field testers' time. The goal of the interview questions is to evoke

vivid descriptions from the field testers regarding what happens and how they feel when using the submarine C4I systems of interest described earlier and explaining what problems they have when using them.

Using these guidelines, the submarine customer product development interview team derived the following set of questions that were used to guide the course of all subsequent interviews with submarine field testers. These questions were designed to gather information regarding the operability and maintainability of the C4I systems of interest installed prior to the most recently completed period of deployed operations as well as the submarine customer voice regarding the installation process.

a. Describe the most demanding communications period that occurred during the deployment and how well or how poorly the new C4I system installations supported the ship during that period?

b. Describe the most difficult maintenance evolution involving the new C4I systems that occurred during the deployment and how well or how poorly the technical documentation supported your maintenance efforts.

c. Describe the training provided during the installation of the new C4I systems and how well or how poorly that training prepared you for operating and maintaining the equipment during your deployment.

d. Describe the impact of the new C4I system installation on the ship's routine/schedule.

e. Are there any other issues or problems with the new C4I systems? Were any Casualty Reports (CASREPS) involving the new C4I systems required during the deployment?

Appendix A provides an example of the interview data sheets developed as part of this study and used to record responses from interviewees.

C. SELECTING FIELD TESTERS TO INTERVIEW

Application of the Harvard Business School's Redesigning Product/Service Development program field tester selection criteria was relatively straightforward as applied to the submarine customer product development interview planning. The first step was to define users versus purchasers. For the submarine C4I systems of interest, the users are the officers and enlisted communications technicians assigned to operational units whereas the purchasers are program office and resource sponsor personnel. As outlined in the L.L. Bean method, the product development interviews were limited to the user community. The second step in selecting submarine field testers is to define experienced users. In this case, the level of experience with the submarine C4I systems of interest was the determining factor. Experienced users were defined as those submarine operators who had recently returned from a six-month deployment while equipped with those systems.

Defining demographic categories in which diverse representation among experienced users is desired constitutes step three of the field tester selection process. For submarine C4I systems, the important demographic diversity consideration is the rank of selected field testers. It is desirable to include experienced users from all ranks that operate the equipment or depend upon its operation to execute the submarine's mission. This results in selection of a broad cross-section of ranks onboard from the junior enlisted communicators (typically a third class petty officer/E-4) to the Commanding Officer (a Commander/O-5). Other

possible demographic categories (gender, geographic location, etc.) were determined to be unimportant for this study.

The final step in determining field tester selection criteria is to define common characteristics for experienced, demographically diverse users. In this regard, L.L. Bean's set of common characteristics for field testers was directly applicable to the desired characteristics of submarine field testers. Specifically, submarine field testers were pursued who were articulate, analytical, honest, unbiased and timely in providing feedback.

In addition to applying the Harvard Business School's step-by-step method to defining submarine field tester selection criteria, two additional considerations specific to the submarine community were used to help select and recruit field testers for this study. These considerations are discussed below.

1. Submarine Deployment Cycles

The typical submarine training and deployment schedule includes eighteen months of in port and underway training in the vicinity of the ship's homeport followed by a six-month duration overseas deployment. The crew's operating expertise in all areas, including communications, can be expected to peak during the overseas deployment when the operational tempo normally requires the submarine to be underway about 75-80 percent of the time. Additionally, the most demanding and intensive communications scenarios occur during the overseas deployment. For these reasons, the ideal submarine field testers would have recently completed an overseas deployment.

2. Submarine Community Input

In order to ensure that selected submarine field testers would be the most proficient and knowledgeable communications personnel available, the submarine force type commanders in the Atlantic and Pacific fleets were consulted and asked to provide their perspective regarding which submarines had consistently demonstrated the highest level of communications expertise. Since the type commander personnel have detailed knowledge of the communications proficiency for all submarines under their command, this input was heavily weighted in selecting the submarine field testers for this study.

Applying the tenets of the Harvard Business School process and including inputs from submarine force operational commanders, four submarines were selected for this study: USS JEFFERSON CITY (SSN 759), USS ASHEVILLE (SSN 758), USS SANTA FE (SSN 763) and USS OLYMPIA (SSN 718). Twenty-two submarine field testers were chosen from the crews of these ships, including two Commanding Officers, two Operations Officers, four Communications Officers, four Communications Leading Chief Petty Officers, five Communications Watch Supervisors and eight Communications Watch Standers.

D. CONDUCT OF INTERVIEWS

Several key tenets of the Harvard Business School's Redesigning Product/Service Development program to obtain the customer voice describe attributes that are specific to the conduct of the interview itself. The following paragraphs describe how the tenets of "Go right to your customers turf", "Listen to your customers face-to-face" and "Watch your customers actually using your products or services" were applied during the submarine communications product development customer interviews (Garvin, 2000, p. 11).

1. Interview Locations

For the submarine community, the customer's turf is easily defined as the submarine itself. All submarine customer product development interviews for this study were conducted face-to-face with selected field testers onboard operational fast attack submarines. Interestingly however, the different demographic groups (officer and enlisted personnel) require slightly different locations onboard the submarine to feel more at ease during the interviews. For officers, the interview location chosen is the submarine wardroom where the officers typically meet for meals and training evolutions on an underway submarine. The wardroom offers a relaxed atmosphere where the officers can comfortably describe their experiences with the C4I systems of interest to this study. For enlisted communications technicians, the radio room offers the best area to interface with the selected field testers as it makes them feel at ease in their working environment and affords the opportunity for them to demonstrate the operation of the products during the conduct of the interview (another key tenet of the L.L. Bean method). All of the submarine C4I systems of interest to this study are physically located in the submarine's radio room.

2. Interview Schedule

The Harvard Business School's process for interviewing field testers requires that the interviews take no more than one hour of the field tester's time. This helps ensure that the field testers enjoy the process and don't feel burdened by it. The L.L. Bean method relies on a small group of motivated field testers to be used again and again to help design new products and improve existing ones. Field testers should perceive the interviews as an opportunity to contribute their ideas to the development of superior products rather than just

another task to add to their already lengthy daily routine. It is particularly important to follow this guideline when working with submarine field testers since they are extremely busy with the day-to-day operations of the submarine. All of the interviews planned for this study were scheduled for a one-hour duration in keeping with the Redesigning Product/Service Development program criteria and to limit the impact on the submarine's in port schedule.

E. CHAPTER SUMMARY

This chapter has described three main areas of research methodology required in this thesis. The first area involved planning the product development interviews to include determining the composition of the interview team and developing the questions to be used during the interview. The second area consisted of selecting field testers from the submarine community to interview. Finally, the third area was the conduct of the interviews themselves. The results of these interviews will be critical in determining the applicability of the Harvard Business School's Redesigning Product/Service Development program to military C4I systems development and to develop useful product requirements for the submarine C4I systems of interest. The following chapters analyze and summarize the results of these submarine customer product development interviews.

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IV. DATA ANALYSIS AND INTERVIEW RESULTS

A. INTRODUCTION

This chapter analyzes interview responses from submarine field testers. Selected submarine crew members answered five open-ended questions regarding the submarine C4I systems of interest and provided recommendations for their improvement. The interview results were analyzed in accordance with the Harvard Business School's Redesigning Product/Service Development method. This chapter discusses the post-interview debriefings conducted immediately following each series of interviews and describes how submarine field tester interview results are translated into summarized quotations and descriptions. These summarized results are then translated into product requirements and design ideas following the L.L. Bean model.

B. INTERVIEW RESULTS

The data for this thesis are the submarine field tester comments recorded during one-on-one interviews with them. Twenty-two carefully selected submarine crew members were interviewed using the L.L Bean product development interview techniques as described above. Interviewee responses were recorded exactly without interpretation, filtering or summary as recommended in the Harvard Business School's Redesigning Product/Service Development Toolkit (Garvin, 2000). Post-interview debriefings were conducted as soon as possible following each series of interviews, and follow-up meetings were held to summarize and translate submarine field tester interview results into product requirements and design ideas.

1. Post-Interview Debriefings

The Harvard Business School program suggests that the interviewer and recorder conduct post-interview debriefings with one another as soon as possible following each interview. This allows the team to review the interview notes and fill in any gaps while the interview is still fresh on their minds. The objective of the debriefings was to capture what the submarine field testers thought and felt most deeply about the submarine C4I systems of interest by selecting the most evocative quotations and vivid descriptions they provided during the interview. Examples of these quotations regarding the submarine C4I systems of interest include:

> "Too many things that we are getting -- a bunch of geek toys -- do we really need them all?"
>
> "The installation process -- they install equipment, they give no tech support, they give us on-the-fly training, they say good bye and have fun. Then, the equipment breaks down and sits idle for the rest of the deployment."
>
> "Biggest problem is lack of time for training -- knowledge not used is knowledge not gained."
>
> "All of this shit is hard to fix – none of it is easy!"

Appendix B provides complete submarine customer product development interview debriefing results arranged by interview question and submarine C4I system of interest.

2. Summarizing field tester Quotations and Descriptions

In accordance with the Harvard Business School method, submarine field tester interviews are summarized and translated in three separate phases. The first phase involves summarizing and pooling field tester quotations and descriptions into general categories. As

an initial step, quotations and descriptions are pooled according to the interview question and system of interest to which they apply. These pooled quotations and descriptions are then prioritized and reduced according to the interview team's understanding of field tester priorities. Any questions regarding field tester priorities are resolved by referring to the interview transcripts. This process continues until the quotations and descriptions are reduced to a manageable number, approximately three to five times the number of team members as defined by the Redesigning Product/Service Development Toolkit (Garvin, 2000). Next, prioritized quotations and descriptions are rearranged into clusters by themes, ignoring the interview questions. Any quotations/descriptions not grouped through this process are evaluated separately according to their perceived importance, referring to the interview transcript as required. These ungrouped quotations/descriptions are then either eliminated or if deemed important enough, they each become a separate group of one. Finally, each cluster of submarine field tester quotations and descriptions are summarized with a brief phrase or statement.

For each of the submarine C4I systems of interest, application of this process led to the following field tester quotation/description summary statements:

a. UHF MDR Capability

1) *Only One User Allowed at a Time*
2) *Inadequate Operator Training*
3) *System Too Slow*
4) *Spare Parts Support Inadequate*
5) *Poor Installation Planning*
6) *No Line of Sight Internet Protocol Communications Capability*

b. Mini-DAMA UHF Transceiver:

1) *Spare Parts Support Inadequate*

2) *Inadequate Operator Training*

3) *Insufficiently Strong Connectors Used*

4) *Proliferation of Laptop Computers in Radio Room is a Problem*

5) *Poor Backwards Compatibility with Earlier Systems*

c. Submarine Tactical Data Links:

1) *Systems Not Operationally Useful*

2) *Inadequate Operator Training/Technical Support*

3) *Inadequate Stowage Available for Hard Copy Technical Manuals*

Recurrence of summary statements regarding inadequate spare parts support and operator training over multiple systems is likely indicative of a systemic problem with submarine C4I system development. Appendix C provides the complete listing of summarized grouped quotations and descriptions developed from the submarine product development interviews as part of this study.

3. Translating Summarized Quotations and Descriptions into Product Requirements

The second phase of the Harvard Business School's Redesigning Product/Service Development method to translate field tester interview results into design ideas involves developing product requirements from the summarized field tester quotations and descriptions. First, each quotation/description summary statement developed above is translated into one or more product requirements. These product requirements are then

prioritized and reduced using a process similar to that used to prioritize and reduce submarine field tester quotations and descriptions. Questions regarding field tester priorities are resolved by referring to interview transcripts or quotation/description sheets. In this way, product requirements are reduced to a manageable number of approximately three to five times the number of team members (Garvin, 2000). Prioritized requirements are then grouped into clusters by themes and any ungrouped requirements are evaluated for elimination or retention based on their importance, referring to quotation/description sheets as necessary. Requirements are reviewed to ensure submarine field tester priorities are accurately captured and no redundancies exist until only essential requirements remain.

For each of the submarine C4I systems of interest, application of this process led to the following product requirements:

a. UHF MDR Capability

1. *System shall allow for multiple simultaneous users.*
2. *Operator training shall address all facets of system operation.*
3. *Operator training shall be made available to all planned operators.*
4. *System shall allow for higher data throughputs.*
5. *System sparing shall provide adequate support for deployed operations.*
6. *System installations shall be planned to minimize submarine schedule impacts.*
7. *System shall provide a Line of Sight Internet Protocol communications capability.*

b. Mini-DAMA UHF Transceiver

1) *System sparing shall provide adequate support for deployed operations.*

2) *Operator training shall address all facets of system operation.*

3) *Operator training shall be made available to all planned operators.*

4) *System connectors shall withstand normal wear and tear to include routine maintenance requirements.*

5) *Operating workstation for the system shall be environmentally qualified with respect to anticipated shock and vibration conditions.*

6) *Operating workstations in the Radio Room shall be consolidated to the maximum extent possible.*

7) *System shall be interoperable with UHF Transceivers in service on other Navy units.*

c. Submarine Tactical Data Links

1) *Systems fielded shall be operationally useful for submarines.*

2) *Non-operationally useful systems shall be removed from submarine Radio Rooms.*

3) *Operator training shall address all facets of system operation.*

4) *Operator training shall be made available to all planned operators.*

5) *Adequate stowage shall be provided for all required hard copy technical manuals and/or technical manuals shall be provided in electronic format.*

Requirements for improved and more readily available training flow naturally from weaknesses identified in all three submarine C4I systems of interest. Improved logistics support is also a recurring requirement across multiple systems. Appendix D presents the complete product requirements listing developed for the submarine C4I systems of interest as part of this study.

4. Translating Product Requirements into Design Ideas

The final phase of summarizing and translating field tester interviews in accordance with the L.L. Bean method begins with brainstorming to produce many product design ideas for each requirement developed in the previous phase. To encourage innovation, no design idea should be considered too "crazy" for consideration. Generated design ideas are then pooled and reduced in a process similar to that used for field tester quotation/descriptions and product requirements. Design ideas are then grouped into clusters by themes, and any ideas not grouped are evaluated for elimination based on their ability to meet the product requirements. The resulting design idea listing is compared to the submarine field tester quotation/description sheets to ensure that the ideas and concerns of the experienced, demographically diverse product users are driving the design idea development (Garvin, 2000).

For each of the submarine C4I systems of interest, application of this process led to the following design ideas:

a. UHF MDR Capability

1) *Multi-User UHF MDR Network – software and hardware upgrades to allow more than one submarine user at a time.*
2) *Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).*
3) *Advanced Digital Waveform – increase system throughput.*
4) *Improved logistics planning – enhance spares support.*

5) *Submarine Installation Planning Team – gather installation lessons learned and improve planning process.*

6) *Battle Force E-mail System – Add this Government Off-The-Shelf (GOTS) system to submarine Radio Rooms to provide a Line of Sight Internet Protocol communications capability.*

b. Mini-DAMA UHF Transceiver

1) *Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).*

2) *Improved logistics planning – enhance spares support.*

3) *Stronger system connectors – upgraded connectors to provide added strength.*

4) *Rugged, consolidated workstations – eliminate problems with laptops and reduce number of workstations.*

5) *Standard Operating Procedure improvements – describe equipment setups required to ensure interoperability with other in service UHF transceivers.*

c. Submarine Tactical Data Links

1) *Common Operating Picture (COP) - new submarine tactical data transfer paradigm required as current legacy systems are clearly not useful in today's submarine operations.*

2) *Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).*

3) *Interactive Electronic Technical Manuals (IETMs) – convert hard copy technical manuals to electronic format.*

Mobile Training Team visits could enhance operator training for all submarine C4I systems of interest. Improved logistics planning would also provide significant benefits across multiple systems. Appendix E lists all submarine C4I system of interest design ideas developed as a result of this study.

E. CHAPTER SUMMARY

The Harvard Business School's Redesigning Product/Service Development process has been applied to develop new design ideas for submarine C4I systems of interest. This chapter described the phases involved in the application of this method to translate submarine field tester interview results into product requirements and design ideas. These design ideas can be used to improve the C4I systems of interest and enhance the development of new submarine C4I systems with similar requirements. The following chapters provide lessons learned and conclusions regarding the application of the Harvard Business School's methodology to military C4I system development and give recommendations for future research.

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V. EVALUATION OF HARVARD BUSINESS SCHOOL PROGRAM APPLIED TO MILITARY C4I SYSTEMS DEVELOPMENT

A. INTRODUCTION

The preceding chapters have detailed an application of the Harvard Business School's Redesigning Product/Service Development program to obtain customer inputs for submarine C4I systems development. This chapter will identify lessons learned through applying the L.L. Bean method for developing new product ideas to submarine systems and generalize these lessons learned to other military systems. Benefits and drawbacks of this method for obtaining operating forces' input to C4I systems development will be identified and obstacles to employing these methods in the military services will be explored. Conclusions and recommendations for further research will then be provided in the final chapter of this paper.

B. BENEFITS OF L.L. BEAN MODEL

The greatest advantage of the Harvard Business School's Redesigning Product/Service Development model as applied to military C4I systems development is its focus on obtaining product design ideas from the true experts in the field, those that actually use the systems to accomplish their assigned missions. By providing a logical and comprehensive framework for capturing the experiences (both good and bad) of the actual customers, the Harvard Business School method enables system developers to capture the true mission need that the system should fulfill and significantly enhances the developers' understanding of the system's operational requirements. By immersing product developers in their customers' experiences through face-to-face interviews on the customer's turf with

an opportunity to watch customers actually using the C4I systems of interest, the L.L. Bean method enhances the intensity of the developer and customer interactions. Gruner and Homburg (2000) have developed a theoretical justification for the positive influence of customer interaction in the product development process using resource dependence theory, and they empirically supported their theory that the intensity of customer interaction in the product development process positively impacts product success through intensive study of the German machinery industry. Their research also suggests that customer interaction is most effective in developing products where a high degree of innovation is required and where the customers have a high level of expertise with respect to the product. Both of these criteria apply strongly to military C4I systems, indicating the importance of involving operational users in the product development process and implying that the customer focus inherent in the L.L. Bean method should lead to product development success.

Another important benefit of the Harvard Business School's Redesigning Product/Service Development program is their methodical approach to identifying customers with an optimal mix of expertise and experience to serve as field testers and provide the necessary user insights into the development process. Gruner and Homburg's (2000) research also supports the hypothesis that the characteristics of the involved customers have a direct impact on product development success. By providing a detailed framework for identifying experienced, demographically diverse users to participate in the product development process, the Harvard Business School method maximizes the potential for a successful outcome. Figure 3 graphically depicts the conceptual framework of Gruner and Homburg's findings with respect to customer interaction and new product success. The L.L.

Bean method integrates both criteria identified by Gruner and Homburg as important to successful product development.

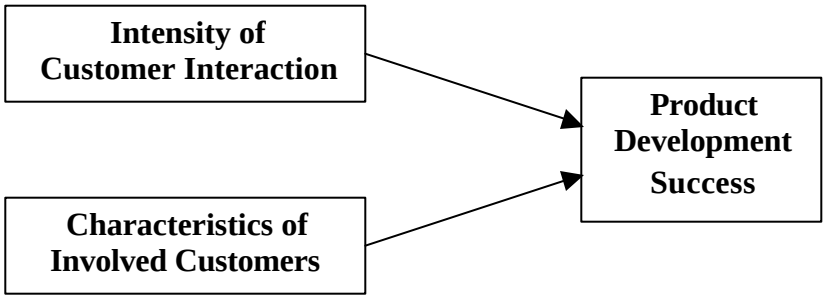

Figure 3: Conceptual Framework for Customer Interaction and New Product Success (From: Gruner and Homburg, 2000)

A final important benefit of the Harvard Business School program is the step-by-step methodology provided to translate customer interview results into essential product requirements and develop design ideas to precisely meet those identified requirements. Each step of this process emphasizes comparison of the result with customer statements of necessary product features to ensure that the ideas and concerns of experienced, demographically diverse product users are continuing to drive the development process. This step by step process to capture customer mission needs and product requirements lends itself well to submarine C4I systems development and helps to ensure that successful outcomes will be repeatable over a wide variety of military C4I systems applications.

C. LIMITATIONS OF L.L. BEAN MODEL

A significant limitation of the Harvard Business School's Redesigning Product/Service Development program is that it requires that experienced customers exist from which to obtain essential product requirements and stimulate design ideas. While this is possible in most product development applications, highly innovative product development efforts may have difficulty identifying field testers to interview. For example, the developer of the first U.S. Navy submarine, John P. Holland, would have encountered significant difficulty in identifying experienced submarine users to participate in his product development process. Thus, there likely exists an upper limit to the capacity of the L.L. Bean method's ability to provide useful input to highly innovative military C4I systems development efforts.

Another limitation of this method is that it addresses customer interaction with product developers only in the early design/concept idea stage of product development. Gruner and Homburg's (2000) research results encourage interaction in the late stages of the product development process (i.e., prototyping and product launch) as well as the early stages. This suggests that other methods in addition to the Harvard Business School program are required to maximize the benefits of customer interaction during the product development process.

C. OBSTACLES TO IMPLEMENTING THE L.L. BEAN MODEL

The most significant obstacle to effective implementation of the Harvard Business School's Redesigning Product/Service Development program in military C4I systems development is the DoD acquisition model itself. The L.L. Bean method is premised upon

direct interaction between experienced users and system developers. Although the DoD acquisition model encourages and requires acquisition and requirements community personnel to interact with the user community to enhance new product developments, it makes no specific provisions for the actual system developers (i.e., defense contractors) to interact on a systematic basis with operational users, particularly in the early stages of concept development. This places the burden for capturing and translating operational user needs and requirements on the acquisition community and risks inaccurately or inadequately conveying the user's intent to the actual system developers. Fortunately, program managers have significant leeway in implementing DoD regulations, and many have already begun to realize the significant advantages that can accrue from promoting direct interaction between operational users and system developers. For example, the Submarine Communications Program Office is effectively applying this technique to enhance the development of the VIRGINIA (SSN 774) Exterior Communications System by periodically sending submarine communications electronics technicians assigned to operational fleet units to the system developer's integration facility, allowing contractor system and software engineers to better understand the operator perspective and integrate it successfully into the final product.

Other less significant obstacles to effectively implementing the Harvard Business School method in military C4I systems development include funding constraints (both the funds required to implement the method as well as funds required to implement design ideas identified through the process) and the training required to teach the method to appropriate program office and system developer personnel. Efficient budgeting and planning practices by the program office and contractor facility are required to overcome these lesser obstacles.

E. CHAPTER SUMMARY

Benefits, limitations and obstacles to implementing the Harvard Business School's Redesigning Product/Service Development process have been outlined in this chapter. The L.L. Bean method effectively applies the tenets of intensity of customer interaction and characteristics of the involved customers researched by Gruner and Homburg. However, this method focuses solely on the early stages of the product development process, and it focuses on direct interaction between operational users and system developers that can be harder to achieve in military systems development. The final chapter provides conclusions regarding the application of the Harvard Business School's methodology to military C4I system development and gives recommendations for future research.

VI. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

This research applied a commercial product development process developed by the Harvard Business School and L.L. Bean, Incorporated to military C4I systems development. The redesigning product/service development program developed by Garvin focuses on interviews of carefully selected, experienced product users in order to better understand the voice of the customer and derive new product requirements and design ideas. Open-ended questions are developed and asked in the users' environment to encourage them to tell a story that captures the essence of their product needs. Interview results are analyzed and congealed into product requirements and design ideas through step-by-step review and analysis. This thesis used this method to capture the voice of the submarine customer as applied to communications, command and control systems.

Research for this thesis included a review of current best commercial practices in injecting customer input into the new product development process. Previous research on applying commercial product development processes to military systems development was also reviewed. In order to gather submariner input, twenty-two officers and enlisted personnel currently assigned to operational submarines were selected as C4I system field testers. These experienced users were interviewed onboard their ships to capture their perspective on system requirements and ideas for improvement.

The interview results were translated into concrete product requirements and design ideas using the step-by-step method recommended by the Harvard Business School program.

Design ideas developed during the course of this research are currently being implemented to improve the effectiveness and user acceptance of submarine C4I systems. Initial results of this implementation are promising. The Submarine C4I Mobile Training Team, in particular, has demonstrated significant success in increasing the ability of the submarine users to operate and maintain new C4I system enhancements effectively. The training team benefited greatly from the data collected as part of this thesis, incorporating the customer insights directly into their curriculum. Feedback from their subsequent training visits to submarines has been overwhelmingly positive. Space and Naval Warfare System Command program offices are currently implementing other design ideas developed through this research, and it's still too early to judge their effectiveness in actual submarine force operations.

In addition to leveraging experienced submarine user operational knowledge to develop concrete design ideas for improving submarine C4I systems, the larger benefit of this thesis is the successful application of a commercially developed product development process in military C4I systems development. The same Harvard Business School program that enhances L.L. Bean's ability to integrate customer input into the development of new hunting boots has demonstrated utility in capturing experienced military user's C4I system product requirements and design ideas as well. The basic tenet of the redesigning product/service development program holds that the customer, not the product designer, is the true system expert. So, it is obviously important to make every effort to accurately capture the voice of the customer early and often in the new product development process. The DoD acquisition system also recognizes the importance of customer (in this case, the warfighter) input into the new product development process. The Mission Needs Statement, developed by the operating forces, marks the initiation of any new system development.

However, as many successful commercial companies have come to realize and the DoD is beginning to understand, a Mission Needs Statement alone is an inadequate vehicle for completely capturing the voice of the customer. A continuing dialogue between the user, requirements and acquisition communities is required to ensure that system developers truly understand the customer's needs and priorities. Further, the defense contractors who actually develop military systems need to be included in this dialogue. This will become increasingly important as we strive to transform the military and our acquisition processes. Admiral Dennis Blair, Commander-in-Chief of the Pacific Command, also espouses this view, labeling it "Acquisition by Adaptation":

> The paradigm for the future should be based on quicker partnerships … putting a prototype system out quickly, then adapting and improving it as it's fielded. The only way to do this is to connect the engineers directly with the fleet and field units, with the acquisition community as enablers for that process, not controllers of it, and the CINC's identifying requirements, setting priorities and providing venue for systems development (Blair, 2001, p. 4).

The Submarine Communications Program Office is embracing this vision by pursuing innovative ways to inject the voice of the submarine warfighter into the development of the VIRGINIA (SSN 774) Exterior Communications System, maximizing the direct interaction of submarine communications technicians assigned to operational fleet units and system developers employed by Lockheed Martin under contract to deliver the system. As an outgrowth of the concepts developed during the course of this thesis, a comprehensive Fleet Operator System Development and Integration Assistance Team has been chartered to directly connect experienced submarine communicators with the engineers developing the next generation of submarine communications systems. Qualified communications

watchstanders and maintenance technicians from afloat units identified by the Commander, Naval Submarine Forces in Norfolk, Virginia will periodically travel to the Lockheed Martin Exterior Communication Systems integration facility in Eagan, Minnesota to participate directly in system development and integration. By placing submarine communications system experts from the user community on site with system developers, this initiative should help ensure that the voice of the submarine warfighter is well represented in the final Exterior Communications System delivered to the Navy and enhance overall submarine customer satisfaction.

B. RECOMMENDATIONS FOR FUTURE RESEARCH

The Harvard Business School's Redesigning Product/Service Development program is only one example of a commercial product development process that can be successfully adapted to identify and inject the voice of the warfighter into military C4I systems development. In support of the DoD's continuing quest for acquisition excellence, this thesis provides five areas to be considered for future research.

1. **Investigate Web-based methods for capturing the voice of the warfighter.** Drazen Prelac's Information Pump (2001) can provide the voice of the customer via the Web and enable customers to compare and contrast desirable product features via web-based interaction with one another. This method also has the distinct advantage of incorporating a scoring method for qualitative and quantitative feedback. This avenue of research is worth pursuing because it may capture the voice of the warfighter more efficiently and with less cost as compared to the Harvard Business School's Redesigning Product/Service Development method.

2. **Explore new methods for increasing direct interface between military system users (warfighters) and product developers (defense contractor engineers).** Benefits from this research would be two-fold. Product developers would gain a better understanding of user needs and requirements, while warfighters would simultaneously gain a better appreciation for military system capabilities and

limitations. These methods should therefore lead to better military products that are more effectively employed in the field.

3. **Conduct a quantitative analysis of the tangible benefits of injecting the voice of the warfighter directly into the new product development process.** This study would entail a comparison of military product developments that used a high degree of experienced user input during the development process with those that involved warfighters to a lesser degree. Quantitative metrics involving specific performance achievements and cost reductions would be developed and analyzed.

4. **Create a database of commercial best practices that have been proven to enhance military systems product development.** The product of this research would become a toolkit allowing government program managers to select commercial techniques that have demonstrated success in military applications.

5. **Apply the Harvard Business School's Redesigning Product/Service Development program methods to the development of an Operational Requirements Document.** This research would apply the same method described in this thesis to a new start military program at the outset to determine if the same type of one-on-one interview process with experienced users can be useful to formulate an Operational Requirements Document for a previously non-existing capability.

Military systems' development can be greatly enhanced by more effectively communicating warfighter requirements to the engineers tasked with designing and building them. Commercial methods for capturing the voice of the customer and ingraining it into the product development process can prove helpful in military applications. Government program managers should strive to increase the exchange of ideas between their warfighter customers and the engineers actually developing the systems under their cognizance. Commercial best practices such as the Harvard Business School's Redesigning Product/Service Development program can help them do it.

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APPENDIX A. PRODUCT DEVELOPMENT INTERVIEW DATA FORMS

a. Describe the most demanding communications period that occurred during the deployment and how well or how poorly the new C4I system installations supported the ship during that period?	
b. Describe the most difficult maintenance evolution involving the new C4I systems that occurred during the deployment and how well or how poorly the technical documentation supported your maintenance efforts.	
c. Describe the training provided during the installation of the new C4I systems and how well or how poorly that training prepared you for operating and maintaining the equipment during your deployment.	
d. Describe the impact of the new C4I system installation on the ship's routine/schedule.	
e. Are there any other issues or problems with the new C4I systems? Were any Casualty Reports (CASREPS) involving the new C4I systems required during the deployment?	

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APPENDIX B. PRODUCT DEVELOPMENT INTERVIEW RESULTS

a. Describe the most demanding communications period that occurred during the deployment and how well or how poorly the new C4I system installations supported the ship during that period?

UHF MDR Capability:

SIPRNET to CTF 12 ASW WECAN limited by satellite time-sharing with other submarine, time broken by odd hour and even hour. WECAN used by a lot of players; function very good – biggest drawback was we had to share.

Continually questioned whether or not the data got off the ship; an example was when we had 8 email messages received we had no indication if the messages were sent really transmitted.

Server at SUBPAC was a challenge; MILSTAR 1 & 2 great reach back to SUBPAC; server there can only support 1 user at a time; degraded capability of the technology (UHF MDR).

Major challenge was that we had no one trained on the exchange server - only one sailor had the training, and he left the ship due to a family emergency.

Time sharing a challenge – cannot always connect to shore server when desired.

UHF MDR Capability with the CHAT software is a neat system.

Convenient way to make required reports.

Biggest limitation is that only one submarine can use it at a time, during one period the SANTA FE used it for 8-10 hours; it appears it is first come, first serve.

So slow – requires too much periscope depth time –extra time at comms depth means mast exposure time is increased.

Sent overlays this way during COMPTUEX -- had to share time with other submarines. Great way to send plans and overlays.

Timeframe for the use of UHF MDR Capability controlled by SUBPAC

a. Describe the most demanding communications period that occurred during the deployment and how well or how poorly the new C4I system installations supported the ship during that period?

Mini-DAMA UHF Transceiver:

Eased operability of Radio Room equipment – less physical twisting and turning.

The biggest problem was the interface with the STENNIS whose crew was relatively new and had not operated with a submarine outfitted with Mini-Dama. They were not familiar with the dual WSC 3 challenge. In Singapore finally figured out the difficulty and then we had the STENNIS make the proper adjustments. Recommend that the Sub Liaison Officer be given good briefing on Mini-DAMA/WSC-3 problems; the people on the CV need education of the capability of the equipment on the submarine; need configuration lineups shared with the BG.

Mini-DAMA was slapped on in a day, had minimal training during the installation.

Mini-DAMA spare cards among all the submarines is inconsistent - no standard spare equipment given with the installation; no standard ready spares; lost a power supply and did not have one to replace it.

Mini-DAMA – great system!

I wish I had DAMA in an all in 1 package (referring to satellite channels assigned).

Mini DAMA Line of Sight communications are limited in range for UHF Link 11.

a. Describe the most demanding communications period that occurred during the deployment and how well or how poorly the new C4I system installations supported the ship during that period?

Submarine Tactical Data Links:

Did not utilize S-TADIL-J very well at all – never used it.

S-TADIL-J – Computer glitch caused BG Computer to go down. Training & Tech support not good – immature system. The idea that this new technology needs to be put in the Fleet quickly with no manuals or tech support or training is flawed.

Had on-the-job training for 2 or 3 days during the Pre-Overseas Movement cycle – this was 5 months prior to deployment so everything the sailors learned was lost. We had very little documentation and the installation was the week before the deployment.

S-TADIL-J – Installed at the last minute; tested the system during installation with the shore rather than out at sea with another submarine or even with CV. This is did not help us at all. Spent countless days, man-hours and contributed to intense frustration trying to get the problem resolved with NCTAMS (sub rate is 19.4) as it turned out all it took was turning a switch at the shore site. No SOP written for the shore or CV to work with the sub with this equipment. Worthless system.

LINK 16 – we never use it. It stays off, it is like a big heater; did not use the entire deployment; BG needs it but never used (with us) it either, did not get any training on it. Only good thing about it, it gave the boat an additional handset in radio; it also grounded out the BRA 34 antenna.

LINK 11 – Never used it either.

Subtract some equipment from the radio room that we do not use.

S-TADIL-J - the hard drives never worked so we never operationally used it on the deployment.

b. Describe the most difficult maintenance evolution involving the new C4I systems that occurred during the deployment and how well or how poorly the technical documentation supported your maintenance efforts.

UHF MDR Capability:

Temporary Alterations – no support for them – when you lose the equipment you lose it for good and there is nothing in place to support the equipment.

Laptops – If you lose it UHF MDR Capability is gone – need bracket to hold it. Cable plug in (RJ45) have to plug into the computer is prone to breakage and is not supported by onboard spares.

Need Intra-BG IP connectivity capability! - Look at LOS IP Capability in addition to UHF MDR Capability

Mini-DAMA UHF Transceiver:

No problems; Tech manual tells what to do.

Hard to get parts – lots of cannibalizations from ship-to-ship required.

Submarine Tactical Data Links:

No space to store manuals - need to have technical manuals published on CD-ROM.

All of this shit is hard to fix – none of it is easy!

All equipment is too hard to fix; we have two new First Class, the junior sailors have no idea about the technical information; do not have time to send all sailors to school with all the installations in the schedule.

c. Describe the training provided during the installation of the new C4I systems and how well or how poorly that training prepared you for operating and maintaining the equipment during your deployment.

UHF MDR Capability:

Insufficient training – only one person was taught, and he has transferred from ship.

Training is effective only if it is on-the-air training, especially for UHF MDR.

The training classes that we did have provided good baseline understanding for networking components.

Underway training better than in port training, but operational issues can impact training.

Good training, but a little too in-depth.

The information was presented well since those that did attend were able provide the information to others.

Training is beneficial to the division but when are going to do it?

Biggest problem is lack of time for training.

Mini-DAMA UHF Transceiver:

Need practical training – especially on-the-air formal training.

The operators need to see how it really works; if we are not able to use with other ships, we can't see if our transmissions are correct or if the equipment is operating the right way.

Hands on training is good, actually operating the equipment is better.

Hands-on on-the-air operation necessary to really learn.

Good operator training conducted by SSC-Charleston ("I would not have been able to operate and maintain Mini-DAMA if I hadn't gone to Charleston")

Big difference between great training next to pier and underway - operating with the equipment is the absolute best training possible.

c. Describe the training provided during the installation of the new C4I systems and how well or how poorly that training prepared you for operating and maintaining the equipment during your deployment.

Submarine Tactical Data Links:

S-TADIL-J – No training provided.

Need another way to check what we are doing (e.g. after a transmission contact the other unit and say "these are my settings what are yours?). Really need other ships' support to do effective training.

S-TADIL-J – Had Saturday morning training; no operator training; the training only dealt with how to load crypto.

S-TADIL-J – 2 hours training, I think, right after it was installed, it has not been turned since then – why do we have it in our radio room?

Knowledge not used is knowledge not gained.

d. Describe the impact of the new C4I system installation on the ship's routine/schedule.
UHF MDR Capability: Need to front-load installations during upkeeps to the maximum extent possible.
Mini-DAMA UHF Transceiver: Entire installation was challenging. Never open front panel door – no reason to open door. Connectors inside are very fragile and if you open door, there is a good chance that you will mess them up. Installation occurred during SRA, shipyard routine worked well with the installation, it was a good time to do it.
Submarine Tactical Data Links: No installation issues.

e. Are there any other issues or problems with the new C4I systems? were any Casualty Reports (CASREPS) involving the new C4I systems required during the deployment?

UHF MDR Capability:

UHF MDR capability was completely successful.

Data Replication took too long; had to wait until replication is done before bringing up UHF MDR Chat, once you start replication you can't do anything else – replicate takes about hour to an hour and a half.

Too many things that we are getting -- a bunch of geek toys -- do we really need them all?

Mini-DAMA UHF Transceiver:

Mini-DAMA: interoperability challenge is the transfer of information between the WSC3 V2/V3 and Mini-DAMA; Have to have 2 WSC3 on DAMA; need to find out what works (equipment) and once it works do not swap it out.

Laptop Computer is the weakest link for the Mini-DAMA system.

Most of the problems experienced had to do with the CVN , more training and procedures need to be given to the CVN .

Mini-DAMA has a faulty back plane issue.

Need a back-up laptop for Mini-DAMA - should be standard parts support. Computers should be considered consumables like repair parts. If Mini-DAMA computer goes out, you have no spares. If it goes down, you lose capability -- each boat should a spare.

Need to consolidate workstations and eliminate proliferation of laptop computers in the Radio Room (Note - Ship had installed a flat screen monitor with a computer workstation (vice laptop) as the Mini-DAMA controller (replaced a broken laptop) for better presentation and a central location of two displays (Mini-DAMA and BBS).

e. Are there any other issues or problems with the new C4I systems? were any Casualty Reports (CASREPS) involving the new C4I systems required during the deployment?

Submarine Tactical Data Links:

S-TADIL-J – Something happened to the hardware outside of the radio room; loss of some executable files, no circuit for each, never used the system – tried to use, but never could get it to come up.

LINK 11 – Not used in Arabian Gulf; Receive only when used – rarely operational.

NO STOWAGE - We have no place to store anything in the radio room. Put the tech manuals on CD/electronic format that will help alleviate some of the problems.

Stowage is a major issue that no one is addressing.

S-TADIL-J: Installed, but not tested.

The process -- they install equipment, they give no tech support, they give us on fly training, they say good bye and have fun, the equipment breaks down and it sits idle.

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APPENDIX C. SUMMARIZED FIELD TESTER QUOTATIONS AND DESCRIPTIONS

UHF MDR Capability:
Summary Statement – Only One User Allowed at a Time Time sharing a challenge – cannot always connect to shore server when desired. Biggest limitation is that only one submarine can use it at a time, during one period the SANTA FE used it for 8-10 hours; it appears it is first come, first serve. SIPRNET to CTF 12 ASW WECAN limited by satellite time-sharing with other submarine, time broken by odd hour and even hour. WECAN used by a lot of players; function very good – biggest drawback was we had to share. Timeframe for the use of UHF MDR Capability controlled by SUBPAC Server at SUBPAC was a challenge; MILSTAR 1 & 2 great reach back to SUBPAC; server there can only support 1 user at a time; degraded capability of the technology (UHF MDR). Sent overlays this way during COMPTUEX -- had to share time with other submarines. Great way to send plans and overlays.
Summary Statement – Inadequate Operator Training Major challenge was that we had no one trained on the exchange server - only one sailor had the training, and he left the ship due to a family emergency. Insufficient training – only one person was taught, and he has transferred from ship. Training is effective only if it is on-the-air training, especially for UHF MDR. Underway training better than in port training, but operational issues can impact training. Good training, but a little too in-depth. The information was presented well since those that did attend were able provide the information to others. Training is beneficial to the division but when are going to do it? Biggest problem is lack of time for training.

UHF MDR Capability (continued):
Summary Statement – System Too Slow So slow – requires too much periscope depth time –extra time at comms depth means mast exposure time is increased. Data Replication took too long; had to wait until replication is done before bringing up UHF MDR Chat, once you start replication you can't do anything else – replicate takes about hour to an hour and a half.
Summary Statement – Spare Parts Support Inadequate Temporary Alterations – no support for them – when you lose the equipment you lose it for good and there is nothing in place to support the equipment. Laptops – If you lose it UHF MDR Capability is gone – need bracket to hold it. Cable plug in (RJ45) have to plug into the computer is prone to breakage and is not supported by onboard spares.
Summary Statement – Poor Installation Planning Too many things that we are getting -- a bunch of geek toys -- do we really need them all? Need to front-load installations during upkeeps to the maximum extent possible.
Summary Statement – No Line of Sight Internet Protocol Communications Capability Need Intra-BG IP connectivity capability! - Look at LOS IP Capability in addition to UHF MDR Capability

Mini-DAMA UHF Transceiver:
Summary Statement – Spare Parts Support Inadequate Hard to get parts – lots of cannibalizations from ship-to-ship required. Mini-DAMA spare cards among all the submarines is inconsistent - no standard spare equipment given with the installation; no standard ready spares; lost a power supply and did not have one to replace it. Need a back-up laptop for Mini-DAMA - should be standard parts support. Computers should be considered consumables like repair parts. If Mini-DAMA computer goes out, you have no spares. If it goes down, you lose capability -- each boat should a spare.
Summary Statement – Inadequate Operator Training Mini-DAMA was slapped on in a day, had minimal training during the installation. Need practical training – especially on-the-air formal training. The operators need to see how it really works; if we are not able to use with other ships, we can't see if our transmissions are correct or if the equipment is operating the right way. Hands on training is good, actually operating the equipment is better. Hands-on on-the-air operation necessary to really learn. Good operator training conducted by SSC-Charleston ("I would not have been able to operate and maintain Mini-DAMA if I hadn't gone to Charleston") Big difference between great training next to pier and underway - operating with the equipment is the absolute best training possible.
Summary Statement – Insufficiently Strong Connectors Used Never open front panel door – no reason to open door. Connectors inside are very fragile and if you open door, there is a good chance that you will mess them up. Mini-DAMA has a faulty back plane issue.

Mini-DAMA UHF Transceiver (continued):

Summary Statement – Proliferation of Laptop Computers in Radio Room is a Problem

Laptop Computer is the weakest link for the Mini-DAMA system.

Need to consolidate workstations and eliminate proliferation of laptop computers in the Radio Room (Note - Ship had installed a flat screen monitor with a computer workstation (vice laptop) as the Mini-DAMA controller (replaced a broken laptop) for better presentation and a central location of two displays (Mini-DAMA and BBS).

Summary Statement – Poor Backwards Compatibility with Earlier Systems

The biggest problem was the interface with the STENNIS whose crew was relatively new and had not operated with a submarine outfitted with Mini-Dama. They were not familiar with the dual WSC 3 challenge. In Singapore finally figured out the difficulty and then we had the STENNIS make the proper adjustments. Recommend that the Sub Liaison Officer be given good briefing on Mini-DAMA/WSC-3 problems; the people on the CV need education of the capability of the equipment on the submarine; need configuration lineups shared with the BG.

Mini-DAMA: interoperability challenge is the transfer of information between the WSC3 V2/V3 and Mini-DAMA; Have to have 2 WSC3 on DAMA; need to find out what works (equipment) and once it works do not swap it out.

Most of the problems experienced had to do with the CVN , more training and procedures need to be given to the CVN .

Submarine Tactical Data Links:

Summary Statement – Systems Not Operationally Useful

Did not utilize S-TADIL-J very well at all – never used it.

LINK 16 – we never use it. It stays off, it is like a big heater; did not use the entire deployment; BG needs it but never used (with us) it either, did not get any training on it. Only good thing about it, it gave the boat an additional handset in radio; it also grounded out the BRA 34 antenna.

LINK 11 – Never used it either.

Subtract some equipment from the radio room that we do not use.

S-TADIL-J - the hard drives never worked so we never operationally used it on the deployment.

LINK 11 – Not used in Arabian Gulf; Receive only when used – rarely operational.

Summary Statement – Inadequate Operator Training/Technical Support

S-TADIL-J – Computer glitch caused BG Computer to go down. Training & Tech support not good – immature system. The idea that this new technology needs to be put in the Fleet quickly with no manuals or tech support or training is flawed.

Had on-the-job training for 2 or 3 days during the Pre-Overseas Movement cycle – this was 5 months prior to deployment so everything the sailors learned was lost. We had very little documentation and the installation was the week before the deployment.

S-TADIL-J – Installed at the last minute; tested the system during installation with the shore rather than out at sea with another submarine or even with CV. This is did not help us at all. Spent countless days, man-hours and contributed to intense frustration trying to get the problem resolved with NCTAMS (sub rate is 19.4) as it turned out all it took was turning a switch at the shore site. No SOP written for the shore or CV to work with the sub with this equipment. Worthless system.
No space to store manuals - need to have technical manuals published on CD-ROM.

All of this shit is hard to fix – none of it is easy!

Summary Statement – Inadequate Operator Training/Technical Support (continued)

All equipment is too hard to fix; we have two new First Class, the junior sailors have no idea about the technical information; do not have time to send all sailors to school with all the installations in the schedule.

S-TADIL-J – No training provided.

Need another way to check what we are doing (e.g. after a transmission contact the other unit and say "these are my settings what are yours?). Really need other ships' support to do effective training.

S-TADIL-J – Had Saturday morning training; no operator training; the training only dealt with how to load crypto.

S-TADIL-J – 2 hours training, I think, right after it was installed, it has not been turned since then – why do we have it in our radio room?

S-TADIL-J – Something happened to the hardware outside of the radio room; loss of some executable files, no circuit for each, never used the system – tried to use, but never could get it to come up.

S-TADIL-J: Installed, but not tested.

The process -- they install equipment, they give no tech support, they give us on fly training, they say good bye and have fun, the equipment breaks down and it sits idle.

Summary Statement – Inadequate Stowage Available for Hard Copy Technical Manuals

NO STOWAGE - We have no place to store anything in the radio room. Put the tech manuals on CD/electronic format that will help alleviate some of the problems.

Stowage is a major issue that no one is addressing.

APPENDIX D. SUBMARINE C4I SYSTEM PRODUCT REQUIREMENTS

UHF MDR Capability:

1. System shall allow for multiple simultaneous users.
2. Operator training shall address all facets of system operation.
3. Operator training shall be made available to all planned operators.
4. System shall allow for higher data throughputs.
5. System sparing shall provide adequate support for deployed operations.
6. System installations shall be planned to minimize submarine schedule impacts.
7. System shall provide a Line of Sight Internet Protocol communications capability.

Mini-DAMA UHF Transceiver:

1. System sparing shall provide adequate support for deployed operations.
2. Operator training shall address all facets of system operation.
3. Operator training shall be made available to all planned operators.
4. System connectors shall withstand normal wear and tear to include routine maintenance requirements.
5. Operating workstation for the system shall be environmentally qualified with respect to anticipated shock and vibration conditions.
6. Operating workstations in the Radio Room shall be consolidated to the maximum extent possible.
7. System shall be interoperable with UHF Transceivers in service on other Navy units.

Submarine Tactical Data Links:

1. Systems fielded shall be operationally useful for submarines.
2. Non-operationally useful systems shall be removed from submarine Radio Rooms.
3. Operator training shall address all facets of system operation.
4. Operator training shall be made available to all planned operators.
5. Adequate stowage shall be provided for all required hard copy technical manuals and/or technical manuals shall be provided in electronic format.

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APPENDIX E. SUMARINE C4I SYSTEM DESIGN IDEAS

UHF MDR Capability:

1. Multi-User UHF MDR Network – software and hardware upgrades to allow more than one submarine user at a time.
2. Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).
3. Advanced Digital Waveform – increase system throughput.
4. Improved logistics planning – enhance spares support.
5. Submarine Installation Planning Team – gather installation lessons learned and improve planning process.
6. Battle Force E-mail System – Add this Government Off-The-Shelf (GOTS) system to submarine Radio Rooms to provide a Line of Sight Internet Protocol communications capability.

Mini-DAMA UHF Transceiver:

1. Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).
2. Improved logistics planning – enhance spares support.
3. Stronger system connectors – upgraded connectors to provide added strength.
4. Rugged, consolidated workstations – eliminate problems with laptops and reduce number of workstations.
5. Standard Operating Procedure improvements – describe equipment setups required to ensure interoperability with other in service UHF transceivers

Submarine Tactical Data Links:

1. Common Operating Picture (COP) - new submarine tactical data transfer paradigm required as current legacy systems are clearly not useful in today's submarine operations
2. Mobile Training Team – Team of system experts dispatched to submarines soon after upgrades installed to provide comprehensive training (classroom and underway operational training).
3. Interactive Electronic Technical Manuals (IETMs) – convert hard copy technical manuals to electronic format

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